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Title: METHOD FOR MEASUREMENT OF ROTATION RATES/ACCELERATIONS USING A ROTATION RATE CORIOLIS GYRO, AS WELL AS A CORIOLIS GYRO WHICH IS SUITABLE FOR THIS PURPOSE

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BACKGROUND

Field of the Invention:

The present invention relates to Coriolis gyroscopes. More particularly, the invention pertains to a method for measurement of accelerations with ~~using~~ a rotation rate Coriolis gyro, and to a Coriolis gyro ~~which is~~ suitable for such ~~this~~ purpose.

Description of the Prior Art

Coriolis gyros (also referred to as "vibration gyros") are ~~being~~ increasingly employed ~~used~~ for navigation. ~~purposes; they have~~ Such devices include a mass system that ~~which~~ is caused to oscillate. The ~~Each~~ mass system generally has a large number of oscillation modes, ~~which are~~ initially independent of one another. ~~In order~~ A specific oscillation mode of the mass system is artificially excited to operate the Coriolis gyro. ~~and this~~ Such mode is referred to in the following text as the "excitation oscillation".

Coriolis forces occur that ~~which~~ draw energy from the excitation oscillation of the mass system When the Coriolis gyro is rotated and ~~thus~~ transmit a further oscillation mode of the mass system ~~which is~~ (referred to below ~~in the following text~~ as the "read

oscillation"). ~~In order~~ The read oscillation is tapped off to determine rotations of the Coriolis gyro and a corresponding read signal is investigated to determine whether any changes have occurred in the amplitude of the read oscillation which represent a measure of ~~the~~ rotation of the Coriolis gyro.

Coriolis gyros may comprise either ~~be in the form of both~~ an open-loop or ~~system and~~ a closed-loop system. In a closed-loop system, the amplitude of the read oscillation is continuously reset to a fixed value (preferably zero) via respective control loops, and the resetting forces ~~are~~ measured.

The mass system of the Coriolis gyro ~~which is also~~ (referred to below ~~in the following text~~ as the "resonator") may ~~in this case~~ be of ~~designed in~~ widely differing designs. ~~ways.~~ For example, it is possible to use an integral mass system. Alternatively, it is possible to split the mass system into separate ~~two~~ oscillators ~~which are~~ coupled to one another via a spring system and capable of ~~can carry out relative~~ movements relative ~~with respect~~ to one another. High dimensional accuracies can be achieved particularly ~~in particular~~ with linear double-oscillator systems that ~~which~~ comprise a coupled system ~~composed~~ of two linear oscillators. In double-oscillator systems, the spring system that ~~which~~ couples the ~~two~~ linear oscillators to one another is, in general, designed so ~~in such a way~~

that the two linear oscillators can be caused to oscillate along a first oscillation axis, with ~~in which case~~ the second oscillator additionally oscillating ~~can additionally carry out oscillations~~ along a second oscillation axis ~~which is~~ at right angles to the first oscillation axis. In such case, the movements of the second oscillator along the second oscillation axis can ~~in this case~~ be regarded as a read oscillation while those ~~and the movements~~ of the first and second oscillators along the first oscillation axis can be regarded as an excitation oscillation.

Linear double-oscillator systems have the disadvantage that the oscillations of the two linear oscillators along the first oscillation axis can cause vibrations or reflections in the gyro frame. ~~In this case,~~ (The "gyro frame" should be understood to be a mechanical, non-oscillating structure in which the oscillators are "embedded", e.g., ~~for example~~ a non-oscillating part of a silicon wafer.) The vibrations or reflections in the gyro frame can, in turn, lead to disturbances (e.g. ~~for example~~ damping effects) to ~~the~~ oscillator movements. For example, the oscillations of the first and second linear oscillators along the first oscillation axis can ~~thus~~ be disturbed by both external vibrations and accelerations which act along the first oscillation axis. Analogously ~~to this~~, external vibrations and accelerations acting ~~which act~~ in the direction of the second oscillation axis can

disturb the oscillations of the second linear oscillator along that ~~this~~ oscillation axis to corrupt the measured rotation rate ~~which~~ in precisely the same way as ~~with~~ all of the other disturbance influences mentioned. ~~– leads to corruption of the measured rotation rate.~~

SUMMARY AND OBJECTS OF THE INVENTION

It is therefore an ~~The~~ object of ~~on which~~ the present invention ~~is based is~~ to provide ~~specify~~ a Coriolis gyro ~~by means of~~ which any disturbance of the read oscillation (i.e., ~~that is to say~~ of the oscillation of the second linear oscillator in the direction of the second oscillation axis) as a result of ~~the~~ disturbance influences ~~mentioned above~~ can be largely avoided.

The present invention addresses the preceding and other objects by providing, in a first aspect, ~~In order to achieve this object, the invention provides~~ a Coriolis gyro. ~~as claimed in patent claim 1. Furthermore, the invention provides a method for measurement of accelerations/rotation rates using a rotation rate Coriolis gyro as claimed in patent claim 7. Advantageous refinements and developments of the idea of the invention can be found in the dependent claims.~~

~~The Coriolis~~ Such gyro ~~according to the invention~~ has a first and a second resonator, ~~which are~~ each in the

form of a coupled system comprising a first and a second linear oscillator. ~~with~~ The first resonator is ~~being~~ mechanically/electrostatically connected/coupled to the second resonator such that the two resonators can be caused to oscillate in antiphase with respect to one another along a common oscillation axis.

In a second aspect, ~~For this reason,~~ the invention provides a method for selective or simultaneous measurement of rotation rates and accelerations with ~~This method uses~~ a rotation rate Coriolis gyro that ~~which~~ has a first and a second resonator. The resonators ~~which~~ are ~~each~~ in the form of a coupled system comprising a first and a second linear oscillator. ~~and in which~~ Rotation rates ~~to be determined~~ are determined by tapping and evaluation of the deflections of the second oscillators. ~~The method has the following steps:~~

In such method, the two resonators are caused to carry out oscillations in antiphase with one another along a common oscillation axis. The deflections of the second oscillators are compared with one another ~~in order~~ to determine an antiphase deflection component that ~~which~~ is a measure of the rotation rate to be measured and/or ~~in order~~ to determine a common in-phase deflection component, which is a measure of the acceleration to be measured. ~~and calculation of~~ The rotation rate/acceleration to be measured is then

calculated from the in-phase deflection component/anti-phase deflection component.

The preceding and other features of the invention will become further apparent from the detailed description that follows. Such description is accompanied by a set of drawing figures. Numerals of the drawing figures, corresponding to those of the written description, point to the features of the invention with like numerals referring to like features of the invention throughout.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic illustration of ~~shows~~ one possible embodiment of a mass system having ~~which comprises~~ two linear oscillators, with corresponding control loops, for exciting ~~which are used to excite~~ the first oscillator.

Figure 2 is a scematic illustration of a ~~shows one~~ possible embodiment of a mass system having ~~which comprises~~ two linear oscillators with corresponding measurement and control loops for a rotation rate Ω and a quadrature bias B_Q, as well as auxiliary control loops for compensation of the quadrature bias B_Q.

Figure 3 is a schematic illustration ~~shows an~~

~~outline sketch~~ of a mass system in accordance with an embodiment of ~~according to~~ the invention, which comprises four linear oscillators, with corresponding measurement and control loops for a rotation rate Ω and a quadrature bias B_Q, as well as ~~the~~ auxiliary control loops for compensation of the quadrature bias.

Figure 4 is a block diagram of an embodiment of a ~~shows one preferred embodiment of the~~ control system for incorporation into a mass system in accordance with that illustrated in Figure 3 above. ~~shown in Figure 3.~~

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

~~Accordingly, the~~ A Coriolis gyro according to the invention has a mass system that ~~which~~ comprises two double-oscillator systems ~~that is to say~~ (two resonators) or four linear oscillators. ~~The~~ Antiphase oscillations of the two resonators with respect to one another ~~in this case~~ result in the center of gravity of the mass system remaining stationary if the two resonators are designed appropriately. This results in the oscillation of the mass system producing no ~~not being able to produce any~~ external vibrations that ~~which in turn~~ would result in disturbances in the form of damping/reflections. ~~Furthermore,~~ External vibrations and accelerations in the direction of the common oscillation axis have no influence on the antiphase movement of the two resonators along the

common oscillation axis.

The first resonator can be coupled to the second resonator <u>(e.g.,</u> ~~for example~~ via a spring system <u>that</u> ~~which~~ connects the first resonator to the second resonator<u>)</u>. A further possibility is to couple the first resonator to the second resonator via an electrostatic field. Both types of coupling may be used <u>either preclusively</u> ~~on their own~~ or in <u>combination.</u> ~~conjunction.~~ It is sufficient, for example, for both resonators to be formed <u>on</u> ~~in~~ a common substrate so that ~~the~~ mechanical coupling is replaced by a mechanical connection ~~which is itself~~ provided by the common substrate.

The configurations of the first and ~~of the~~ second <u>resonators</u> ~~resonator~~ are preferably identical in ~~terms of~~ mass and shape. ~~In this case,~~ The two resonators may be arranged axially symmetrically with respect to one another with <u>reference</u> ~~respect~~ to an axis of symmetry ~~which is~~ at right angles to the common oscillation axis. That is, ~~to say~~ the first resonator is mapped by the axis of symmetry onto the second resonator. ~~However,~~ The invention is not restricted to this and it is sufficient for the two resonators to have the same mass, but to be designed with different shapes.

As ~~already~~ mentioned, the coupled resonators

are designed so ~~in such a way~~ that both linear oscillators of a resonator can be caused to oscillate in antiphase along a first oscillation axis (excitation oscillation). ~~and~~ The second linear oscillator can additionally be caused to oscillate along a second oscillation axis (read oscillation). If the first and ~~the~~ second oscillation axes are at right angles to one another, and both ~~resonators~~ are caused to oscillate in antiphase with respect to one another along the first oscillation axis (common oscillation axis), then the second oscillators are deflected in the opposite direction during rotation of the Coriolis gyro (antiphase deflection). ~~while,~~ In contrast, during acceleration of the Coriolis gyro, the second linear oscillators are deflected in the same direction (in-phase deflection). It is thus possible to measure accelerations or rotations selectively. The acceleration is measured by evaluation of an in-phase oscillation, and ~~the~~ rotation rate is measured by evaluation of an antiphase oscillation. ~~In the following text,~~ The expressions "in-phase" and "antiphase" have the following meanings: if the coordinates in the excitation direction are denoted x and those in the read direction are denoted y, then $x_1 = x_2$, $y_1 = y_2$ for in-phase oscillation and $x_1 = -x_2$, $y_1 = -y_2$ for antiphase oscillation (in this case, the index "1" denotes the first oscillator, and the index "2" the second oscillator).

The common in-phase deflection component is determined advantageously as follows: a first quadrature bias ~~which occurs~~ within the first resonator and a second quadrature bias ~~which occurs~~ within the second resonator are determined. The first and the second quadrature biases are then added and subtracted ~~in order~~ to determine a common quadrature bias component (in-phase component) and a difference quadrature bias component (antiphase component). The common quadrature bias component is proportional to the acceleration to be measured and corresponds to the common in-phase deflection component. The difference quadrature bias component (difference) corresponds to the antiphase deflection component. ~~The~~ Rotation rate can thus be measured at the same time as ~~the~~ acceleration, via the difference quadrature bias component.

In order to assist understanding of the acceleration measurement principle described above, the physical principles of a Coriolis gyro will be briefly explained ~~once~~ again <u>below</u> ~~in the following description,~~ using the example of a linear double-oscillator system. In general, Coriolis gyros have a quadrature bias <u>(i.e.,</u> ~~that is to say~~ a zero error<u>)</u>. The quadrature bias is ~~in this case~~ composed of a plurality of quadrature bias components. One of these ~~quadrature bias~~ components arises from alignment errors of the first and second linear oscillator with respect

to one another, with such ~~these~~ alignment errors being unavoidable due to ~~because of~~ manufacturing tolerances. The alignment errors between the two oscillators produce a zero error in the measured rotation rate signal.

The Coriolis force can be represented as:

$$\vec{F} = 2m\vec{v}_s x\vec{\Omega} \qquad [1]$$

$\vec{F}$ *Coriolis force*

m *Mass of the oscillator*

$\vec{v}_s$ *Velocity of the oscillator*

$\vec{\Omega}$ *Rotation rate*

If the mass that ~~which~~ reacts to the Coriolis force is equal to the oscillating mass, and ~~if~~ the oscillator is operated at the natural frequency ω, then:

$$2m\vec{v}_s x\vec{\Omega} = m\vec{a}_c \qquad [2]$$

The oscillator velocity is given by:

$$\vec{v}_s = \vec{v}_{s0}\sin\omega t \qquad [3]$$

where

$\vec{v}_{s0}$ oscillator amplitude

ω = natural frequency of the oscillator

The oscillator and Coriolis accelerations are

thus given by:

$$\vec{a}_s = \vec{v}_{s0}\omega\cos\omega t$$
$$\vec{a}_c = 2\vec{v}_{s0}\sin\omega t \times \vec{\Omega}$$

The two acceleration vectors are thus spatially at right angles to one another and are offset through 90° with respect to one another in the time function (spatial and time orthogonality).

These two criteria can be employed ~~used in order~~ to separate ~~the~~ oscillator acceleration $\vec{a}_s$ from the Coriolis acceleration $\vec{a}_c$. The ratio of the abovementioned acceleration amplitudes a_c and a_s is:

$$\frac{a_c}{a_s} = \frac{2\Omega}{\omega} \qquad [5]$$

If the rotation rate is Ω = 5°/h and the natural frequency of the oscillator is f_s = 10 KHz, then:

$$\frac{a_c}{a_s} = 7.7 \cdot 10^{-10} \qquad [6]$$

For an accuracy of 5°/h, undesirable couplings of the first oscillator to the second oscillator must not exceed 7.7 • 10^{-10}, or must be constant. ~~at this value~~ If a mass system composed of two linear oscillators ~~is used, which are~~ coupled to one another via spring elements is employed, then the

accuracy of the spatial orthogonality between the oscillation mode and the measurement mode is limited due to ~~because of~~ the alignment error of the spring elements. ~~The~~ Achievable accuracy (limited by manufacturing tolerances) is 10^{-3} to 10^{-4}. ~~The accuracy of the~~ Time orthogonality accuracy is limited by the phase accuracy of the electronics at, for example, 10 KHz, which can likewise be complied with only to at most 10^{-3} to 10^{-4}. This means that the ratio of the accelerations as defined above cannot be satisfied.

Realistically, the resultant error in the measured acceleration ratio a_c/a_s is:

$$\frac{a_c}{a_s} = 10^{-6} \ to \ 10^{-8}$$

The spatial error results in a so-called quadrature bias B_Q, which, together with the time phase error Δ_ϕ, results in a bias B:

$B_Q = 6.5 \cdot 10^6 \ °/h$ to $6.5 \cdot 10^5 \ °/h$

$\Delta_\phi = 10^{-3}$ to 10^{-4}

$B = B_Q \cdot \Delta_\phi = 6{,}500 \ °/h$ to $65 \ °/h$ [8]

The quadrature bias thus results in a major limitation ~~restriction~~ to ~~the~~ measurement accuracy. In this case, it should be noted that the preceding ~~above~~ error analysis takes account only of the direct coupling of the oscillation mode to the read mode. Further quadrature bias components also exist and occur, for example, as a result of couplings with other

oscillation modes.

If the Coriolis gyro is designed so ~~in such a way~~ that the first oscillators are connected by first spring elements to a gyro frame of the Coriolis gyro, and the second oscillators are connected by second spring elements to ~~in each case~~ one of the first oscillators, then the acceleration to be measured results in a change in the mutual alignment of the first oscillators with respect to the second oscillators. ~~and~~ This is particularly ~~in particular~~ manifested in a change in ~~the~~ alignment of the second spring elements. The alignment change of the second spring elements in ~~this~~ such case produces an "artificial" quadrature bias component (i.e., ~~that is to say~~ an "error") in the quadrature bias signal. It is thus also indirectly possible to use the determination of the quadrature bias to deduce the acceleration to be measured, which produces the corresponding "artificial" quadrature bias component.

The alignments of the first and second spring elements are preferably at right angles to one another. The spring elements may have any desired shape. The expression "first quadrature bias" and "second quadrature bias" ~~in each case~~ preferably mean the total quadrature bias of a resonator. ~~However,~~ It is also possible in the acceleration measurement method according to the invention to ~~in each case~~ determine

only one quadrature bias component in each resonator. In <u>such</u> ~~which~~ case the determined quadrature bias component must include at least <u>the</u> ~~that~~ component ~~which is~~ produced by the acceleration to be measured or the rotation to be measured.

The Coriolis gyro preferably has a device for determination of first rotation rate and quadrature bias signals <u>that</u> ~~which~~ occur within the first resonator, and second rotation rate and quadrature bias signals <u>that</u> ~~which~~ occur within the second resonator. Furthermore, the Coriolis gyro may have a device for production of electrostatic fields, by means of which the alignment angle of the first spring elements with respect to the gyro frame can be varied and/or the alignment angle of the second spring elements can be varied with respect to the first oscillators. The alignment/strength of the electrostatic fields can then be regulated by provision of appropriate control loops <u>so</u> ~~such~~ that the first and the second quadrature bias are in each case as small as possible. A computation unit can use the first and second rotation rate/quadrature bias signals to determine the rotation rate, and ~~can use~~ an in-phase component of the electrostatic fields which compensate for the first and second quadrature biases, to deduce the acceleration to be measured.

The quadrature bias is thus preferably

eliminated at its point of origin. ~~itself, that is to say~~ mechanical alignment errors of the two oscillators with respect to one another and changes in the mutual alignment of the two oscillators caused by the acceleration/rotation to be measured are compensated ~~for~~ by ~~means of~~ an electrostatic force produced by the electrostatic field <u>that</u> ~~which~~ acts on one or both oscillators. ~~and is~~ This type of quadrature bias compensation has the advantage that both rotation rates and accelerations can be determined with increased measurement accuracy.

In one ~~particularly~~ preferred embodiment, the electrical fields change the alignment angles of the first and second spring elements ~~in order~~ to make the alignments of the first and second spring elements orthogonal ~~with respect~~ to one another. Orthogonalization ~~such as this~~ results in compensation for the quadrature bias (component) produced. ~~in this way~~ Further contributions to the quadrature bias are used to set the error angle with respect to orthogonality <u>so</u> ~~such~~ that the overall quadrature bias disappears. The alignment angles of the second spring elements with respect to the first oscillator are preferably varied by ~~means of~~ the electrostatic field, and the alignment angles of the first spring elements with respect to the gyro frame of the Coriolis gyro are not changed. ~~However,~~ It is also possible to use the electrostatic field to vary only the alignment angles

of the first spring elements or to vary the alignment angles of both the first and ~~the~~ second spring elements.

One ~~particularly~~ preferred embodiment of a Coriolis gyro according to the invention has:

- an ("overall") resonator, which is in the form of a system comprising two coupled first (linear) oscillators ("sub-resonators") ~~which are~~ excited in antiphase and each containing ~~contain~~ a second linear read oscillator,
- a device for production of at least one electrostatic field, by means of which the alignment of the two coupled first oscillators with respect to the second (read) oscillators can be varied,
- a device for determination of the quadrature biases of the read oscillators that ~~which~~ are caused by alignment errors of the two oscillators with respect to the excitation oscillator and further coupling mechanisms,
- a control loop which in each case regulates the intensity of the at least one electrostatic field by means of at least one corresponding control signal such that the determined quadrature biases are as small as possible,
- a computation unit, which in each case forms differences and sums of the at least one control signal and uses them to determine the rotation rate and the acceleration.

In principle, it is possible to calculate accelerations and rotation rates solely ~~just~~ on the basis of the determined quadrature biases. ~~that is to say~~ It is not absolutely essential to compensate for the first and second quadrature bias ~~in order~~ to determine the quadrature biases. However, this is advisable for measurement accuracy ~~reasons, since~~ as phase tolerances results in mixing the rotation rate and the quadrature ~~being mixed~~ with one another. The invention covers both alternatives.

It has also been found ~~to be~~ advantageous for each of the second oscillators to be attached to or clamped ~~in~~ on the first oscillator "at one end" in the resonators. "Clamped in at one end" can ~~in this case~~ be understood not only in the sense of the literal wording but also in a general sense. In general, attached or clamped in at one end means that the force is introduced from the first oscillator to the second oscillator essentially from one "side" of the first oscillator. If, ~~by way of~~ for example, the oscillator system were to be designed in such a way that the second oscillator were ~~is~~ bordered by the first oscillator and ~~is~~ connected to it by ~~means of~~ second spring elements, then the expression clamped in or attached at one end would imply the following: the second oscillator is readjusted for the movement by the first oscillator, by the first oscillator alternately

"pushing" or "pulling" the second oscillator by means of the second spring elements.

Clamping the second oscillator in at one end on the first oscillator has the advantage that, when an electrostatic force is exerted on the second oscillator as a result of the alignment/position change of the second oscillator ~~which results from this,~~ the second spring elements can be slightly curved, thus making it possible, without any problems, to vary the corresponding alignment angle of the second spring elements. If the second oscillator ~~in this example~~ were to be attached to additional second spring elements so ~~in such a way~~ that, during movement of the first oscillator, the second oscillator were at the same time to be "pulled" and "pushed" by the second spring elements, then this would be equivalent to the second oscillator being clamped in or attached "at two ends" to the first oscillator (with the force being introduced to the second oscillator from two opposite ends of the first oscillator). In such ~~this~~ case, the additional second spring elements would produce corresponding opposing forces when an electrostatic field is applied, so that changes in the alignment angles of the second spring elements could be achieved only with difficulty. However, clamping in at two ends is acceptable when the additional second spring elements are designed so ~~such~~ that the influence of these spring elements is small so that all of the

spring elements can bend without any problems. ~~in this case as well,~~ That is, ~~to say~~ the clamping in is effectively at one end.

Depending on the design of the oscillator, ~~structure~~ clamping in at one end can be effectively provided just by the "influence" (force introduction) of the additional second spring elements being 40% or less. However, this value does not present any limitation on ~~restriction to~~ the invention. ~~and~~ It is also feasible for the influence of the second spring elements to be more than 40%. ~~By way of~~ For example, clamping in at one end can be achieved by all of the second spring elements that ~~which~~ connect the second oscillator to the first oscillator being arranged parallel and on the same plane. ~~as one another~~ All start and end points of the second spring elements are in each case attached to the same ends of the first and second oscillator. The start and end points of the second spring elements may ~~in this case~~ each advantageously be on a common axis, with the axes intersecting the second spring elements at right angles.

If the second oscillator is attached to or clamped on the first oscillator at one end, then the first spring elements are preferably designed to ~~such that they~~ clamp the first oscillator in on the gyro frame at two ends (the expressions "at one end" and "at

two ends" can be used analogously ~~here~~). As an alternative, ~~to this~~ however, it is possible for the spring elements also to be designed to ~~in such a way that they~~ clamp in the first oscillator at one end. ~~By way of~~ For example, all the first spring elements that ~~which~~ connect the first oscillator to the gyro frame of the Coriolis gyro can be arranged parallel and on the same plane as one another, with the start and end points of the first spring elements in each case preferably being located on a common axis. It is equally possible for the spring elements to be designed so ~~in such a way~~ that the first oscillator is clamped in on the gyro frame at one end, and the second oscillator is clamped in at two ends by the first oscillator. It is also possible for both oscillators to be clamped in at two ends. For quadrature bias compensation, it has been found to be advantageous for at least one of the two oscillators to be clamped in at one end.

~~The invention will be explained in more detail in the following text with reference to one exemplary embodiment in the figures, in which:~~

Figure 1 illustrates ~~shows~~ the schematic design of a linear double oscillator 1 with corresponding electrodes including ~~as well as~~ a block diagram of associated evaluation/excitation electronics 2. The linear double oscillator 1 is preferably

produced by ~~means of~~ etching ~~processes from~~ a silicon wafer. ~~and~~ It has a first linear oscillator 3, a second linear oscillator 4, first spring elements 5_1 to 5_4, second spring elements 6_1 and 6_2 as well as parts of an intermediate frame 7_1 and 7_2 and ~~of~~ a gyro frame 7_3 and 7_4. The second oscillator 4 is mounted within the first oscillator 3 to ~~such that it can~~ oscillate, and is connected to it via the second spring elements 6_1, 6_2. The first oscillator 3 is connected to the gyro frame 7_3, 7_4 by ~~means of~~ the first spring elements 5_1 to 5_4 and the intermediate frame 7_1, 7_2.

~~Furthermore,~~ First excitation electrodes 8_1 to 8_4, first read electrodes 9_1 to 9_4, second excitation electrodes 10_1 to 10_4, and second read electrodes 11_1 and 11_2 are also provided. All of the electrodes are mechanically connected to the gyro frame, although ~~but are~~ electrically isolated. (The expression "gyro frame" refers to ~~means~~ a mechanical, non-oscillating structure in which the oscillators are "embedded", e.g., ~~for example~~ the non-oscillating part of the silicon wafer).

When ~~If~~ the first oscillator 3 is excited by ~~means of~~ the first excitation electrodes 8_1 to 8_4 to oscillate in the X1 direction, such ~~then this~~ movement is transmitted through the second spring elements 6_1, 6_2 to the second oscillator 4 (alternate "pulling" and "pushing"). The vertical alignment of the first spring elements 5_1 to 5_4 prevents the first oscillator 3 from

moving in the X2 direction. However, ~~a~~ vertical oscillation can be carried out by the second oscillator 4 as a result of the horizontal alignment of the second spring elements 6_1, 6_2. When corresponding Coriolis forces ~~accordingly~~ occur, then the second oscillator 4 is excited to oscillate in the X2 direction.

A read signal that ~~which~~ is read from the first read electrodes 9_1 to 9_4 and ~~is~~ proportional to the amplitude/frequency of the X1 movement of the first oscillator 3 is supplied, via appropriate amplifier elements 21, 22 and 23, to an analog/digital converter 24. An appropriately digitized output signal from the analog/digital converter 24 is demodulated ~~not only~~ by a first demodulator 25 and ~~but also~~ by a second demodulator 26 to form corresponding output signals, with the two demodulators operating with an offset of 90° with respect to one another. The output signal from the first demodulator 25 whose output signal controls a frequency generator 30 so ~~such~~ that the signal occurring ~~which occurs~~ downstream from the demodulator 25 is regulated at zero is supplied to a first regulator 27 ~~in order~~ to regulate the frequency of the excitation oscillation (the oscillation of the mass system 1 in the X1 direction). Analogously ~~to this,~~ the output signal from the second demodulator 26 is regulated at a constant value ~~which is~~ (predetermined by the electronics component 29). A second regulator 31 insures ~~ensures~~ that the amplitude of the excitation

oscillation is regulated. The output signals from the frequency generator 30 and ~~from~~ the amplitude regulator 31 are multiplied by one another at ~~by means of~~ a multiplier 32. An output signal from the multiplier 32, ~~which is~~ proportional to the force to be applied to the first excitation electrodes 8_1 to 8_4, acts not only on a first force/voltage converter 33 but also on a second force/voltage converter 34, which use the digital force signal to produce digital voltage signals. The digital output signals from the force/voltage converters 33, 34 are converted by ~~via a~~ first and ~~a~~ second digital/analog converters ~~converter~~ 35, 36 to corresponding analog voltage signals. ~~which are~~ Such signals are then passed to the first excitation electrodes 8_1 to 8_4. The first ~~regulator 27~~ and ~~the~~ second regulators ~~regulator~~ 27, 31 readjust the natural frequency of the first oscillator 3 and set the amplitude of the excitation oscillation to a specific, predeterminable value.

When Coriolis forces occur, resultant ~~the~~ movement of the second oscillator 4 in the X2 direction (read oscillation) ~~that results from this~~ is detected by the second read electrodes 11_1, 11_2, and a read signal, ~~which is~~ proportional to the movement of the read oscillation, is supplied via appropriate amplifier elements 40, 41 and 42 to an analog/digital converter 43 (see Figure 2). A digital output signal from the analog/digital converter 43 is demodulated by a third

demodulator 44 in phase with the direct-bias signal and ~~is~~ demodulated by a fourth demodulator 45, offset through 90°. A corresponding output signal from the first demodulator 44 is applied to a third regulator 46, whose output signal is a compensation signal that ~~and~~ corresponds to the rotation rate Ω to be measured. An output signal from the fourth demodulator 45 is applied to a fourth regulator 47 whose output signal is a compensation signal ~~and is~~ proportional to the quadrature bias to be compensated. ~~for~~ The output signal from the third regulator is modulated by ~~means of~~ a first modulator 48, and the output signal from the fourth regulator 47 is modulated in an analogous manner ~~to this~~ by ~~means of~~ a second modulator 49, so that amplitude-regulated signals are produced whose frequencies correspond to the natural frequency of the oscillation in the X1 direction (sin ≅ 0°, cos ≅ 90°). Corresponding output signals from the modulators 48, 49 are added in an addition stage 50, whose output signal is supplied both to a third force/voltage converter 51 and to a fourth force/voltage converter 52. The corresponding output signals for the force/voltage converters 51, 52 are supplied to digital/analog converters 53, 54, whose analog output signals are applied to the second excitation electrodes 10_2 to 10_3, and reset the oscillation amplitudes of the second oscillator 4.

The electrostatic field ~~which is~~ produced by

the second excitation electrodes 10_1 and 10_4 (or the two electrostatic fields ~~which are~~ produced by the electrode pairs 10_1, 10_3 and 10_2, 10_4) results in an alignment/position change of the second oscillator 4 in the X2 direction, and thus in a change in the alignments of the second spring elements 6_1 to 6_2. The fourth regulator 47 regulates the signal ~~which is~~ applied to the second excitation electrodes 10_1 and 10_4 so ~~in such a way~~ that the quadrature bias ~~which is~~ included in the compensation signal of the fourth regulator 47 is as small as possible, or disappears. A fifth regulator 55, a fifth and a sixth force/voltage converter 56, 57 and two analog/digital converters 58, 59 are used for this purpose.

The output signal from the fourth regulator 47, which is a measure of the quadrature bias, is supplied to the fifth regulator 55, that ~~which~~ regulates the electrostatic field ~~that is~~ produced by the two excitation electrodes 10_1 and 10_4 so that ~~in such a way that~~ the quadrature bias B_Q disappears. ~~For this purpose,~~ An output signal from the fifth regulator 55 is ~~in each case~~ supplied to the fifth and sixth force/voltage converters 56, 57, for this, employing ~~which use~~ the digital force/output signal from the fifth regulator 55 to produce digital voltage signals that ~~These~~ are then converted to analog voltage signals in the analog/digital converters 58, 59. The analog output signal from the analog/digital converter 58 is

supplied to the second excitation electrode 10_1 ~~or~~ (alternatively to electrode 11_1). The analog output signal from the analog/digital converter 59 is supplied to the second excitation electrode 10_4 ~~or~~ (alternatively to electrode 11_2).

As ~~Since~~ the second oscillator 4 is clamped ~~in~~ only by the second spring elements 6_1 to 6_2 (~~clamping~~ clamped ~~in~~ at one end), such ~~the~~ alignment of the ~~these~~ spring elements can be varied without problem by the electrostatic field ~~any problems~~. It is additionally ~~also~~ possible to provide additional second spring elements, ~~which result~~ resulting in the second oscillator 4 being clamped ~~in~~ at two ends, provided that such ~~these~~ additional ~~spring~~ elements are appropriately designed to insure ~~ensure~~ that clamping ~~in~~ at one end is effective. ~~effectively achieved.~~ In order to permit ~~allow~~ the same effect for the spring elements 5_1, 5_2 (and for the spring elements 5_3, 5_4 as well) the third and fourth spring elements 5_3, 5_4, as well as ~~and~~ the first and second spring elements 5_1, 5_2 may be omitted, ~~thus~~ resulting in the first oscillator 3 being clamped ~~in~~ at one end (together with an appropriately modified electrode configuration, ~~which is~~ not shown ~~here~~). In such a situation ~~such as this,~~ the second oscillator 4 ~~could~~ may also be attached to the first oscillator by ~~means of~~ further spring elements ~~in order~~ to achieve clamping ~~in~~ at two ends.

A ~~One~~ preferred embodiment of the Coriolis gyro of ~~according to~~ the invention as well as ~~and~~ its method of operation will be described in more detail ~~in the following description~~ with reference to Figure 3, a schematic illustration of a mass system comprising four linear oscillators with corresponding measurement and control loops for rotation rate and quadrature mass, as well as auxiliary control loops for compensation of the quadrature bias. ~~Figure 3 shows~~ The schematic layout of coupled system 1' comprises ~~comprising~~ a first resonator 70_1 and a second resonator 70_2. The first resonator 70_1 is coupled to the second resonator 70_2 by ~~via~~ a mechanical coupling element (a spring) 71. The first and the second resonator 70_1, 70_2 are formed in a common substrate and may ~~can~~ be caused to oscillate in antiphase with respect to one another along a common oscillation axis 72. The first and ~~the~~ second resonators ~~resonator~~ 70_1, 70_2 are identical, and are mapped onto one another via an axis of symmetry 73. The design of the first and ~~of the~~ second resonator 70_1, 70_2 has ~~already~~ been explained in conjunction with Figures 1 and 2 and will therefore not be explained again. (Identical and mutually corresponding components or component groups are identified by the same reference numbers with identical components ~~which are~~ associated with different resonators being identified by different indices.)

A ~~One~~ major difference between the double

oscillators shown in Figure 3 and those ~~the double oscillators shown~~ in Figures 1 and 2 is that some of the individual electrodes are physically combined to form one overall electrode. For example, the individual electrodes ~~which are~~ identified by the reference numbers 8_1, 8_2, 9_1 and 9_2 in Figure 3 ~~thus~~ form a common electrode. Further, ~~Furthermore,~~ the individual electrodes ~~which are~~ identified by the reference numbers 8_3, 8_4, 9_3 and 9_4 form a common electrode, ~~and~~ those with the reference numbers 10_4, 10_2, 11_2 as well as the reference numbers 11_1, 10_3 and 10_1 each form an overall electrode. The same applies in an analogous manner to the other double-oscillator system.

During operation of the coupled system 1' in accordance with ~~according to~~ the invention, the two resonators 70_1, 70_2 oscillate in antiphase along the common oscillation axis 72. The coupled system 1' is thus not susceptible to external disturbances or to those ~~disturbances which are~~ emitted by the coupled system 1' itself into the substrate in which the resonators 70_1 and 70_2 are mounted.

When the coupled system 1' is rotated, ~~then~~ the second oscillators 4_1 and 4_2 are deflected in mutually opposite directions (i.e., ~~in~~ the X2 direction and ~~in the~~ opposite ~~direction~~ to the X2 direction). When an acceleration of the coupled system 1' occurs, ~~then~~ the second oscillators 4_1, 4_2 are each deflected in

the same direction, i.e. ~~specifically~~ in the same direction as the acceleration provided that such ~~this~~ acceleration is in the X2 direction, or in the opposite direction. ~~to it~~ Accelerations and rotations can thus be measured simultaneously or selectively. Quadrature bias compensation can be carried out ~~at the same time~~ during the measurement process in the resonators 70_1, 70_2. However, this is not absolutely essential.

In principle, it is possible to operate the coupled system 1' on the basis of the evaluation/excitation electronics 2 described with reference to ~~in~~ Figures 1 and 2. ~~However,~~ An alternative method (carrier frequency method) is ~~used~~ instead used ~~of this~~ in the embodiment of ~~shown in~~ Figure 3. Such ~~This~~ operating method will be described below. ~~in the following text.~~

The evaluation/excitation electronics 2 ~~which are~~ identified by the reference number 2' include ~~have~~ three control loops: a first control loop for excitation and/or control of an antiphase oscillation of the first oscillators 3_1 and 3_2 along the common oscillation axis 72, a second control loop for resetting and compensation of the oscillations of the second oscillator 4_1 along the X2 direction, and a control loop for resetting and compensation of the oscillations of the second oscillator 4_2 along the X2 direction. The three described control loops include

~~have~~ an amplifier 60, an analog/digital converter 61, a signal separation module 62, a first to third demodulation module 63_1 to 63_3, a control module 64, an electrode voltage calculation module 65, a carrier frequency addition module 67, and a first to sixth digital/analog converter 66_1 to 66_6.

Carrier frequencies can be applied to the electrodes 8_1 to 8_8, 9_1 to 9_8, 10_1 to 10_8 and 11_1 to 11_4 for tapping excitation of the antiphase oscillation or of the oscillations of the second oscillators 4_1, 4_2. This may be accomplished in a number of ways. They include : a) using three different frequencies, with one frequency ~~being~~ associated with each control loop, b) using square-wave signals with a time-division multiplexing method, and ~~or~~ c) using random phase scrambling (stochastic modulation method).

The carrier frequencies are applied to the electrodes 8_1 to 8_8, 9_1 to 9_8, 10_1 to 10_8 and 11_1 to 11_4 via the associated signals UyAo, UyAu (for the second oscillator 4_1), ~~and~~ Uxl, Uxr (for the antiphase resonance of the first oscillators 3_1 to 3_2) and ~~as well as~~ UyBu and UyBo (for the second oscillator 4_2) that ~~which~~ are produced in the carrier frequency addition module 67 and ~~are~~ excited in antiphase with respect to the abovementioned frequency signals. The oscillations of the first and second oscillators 3_1, 3_2, 4_1 and 4_2 are tapped off via those parts of the gyro frame ~~which are~~

identified by the reference numbers 7_7, 7_9, 7_{11} and 7_{13}, ~~and in this case are additionally~~ (used as tapping electrodes in addition to their function as suspension points for the mass system). For this ~~purpose,~~ the two resonators 70_1, 70_2 are preferably ~~and advantageously~~ designed to be electrically conductive, with all of the frames, springs and connections. The signal, ~~which is~~ tapped off by means of the gyro frame parts 7_7, 7_9, 7_{11} and 7_{13} and ~~is~~ supplied to the amplifier 60, contains information about all three oscillation modes. It ~~and~~ is converted by the analog/digital converter 61 to a digital signal ~~which is~~ supplied to the signal separation module 62.

The assembled signal is separated into three different signals in the signal separation module 62: x (which contains information about the antiphase oscillation), yA (which contains information about the deflection of the second oscillator 4_1) and ~~as well as~~ yB (which contains information about the deflection of the second oscillator 4_2). The signals are separated differently in accordance with ~~depending on~~ the type of carrier frequency method ~~used~~ (see a) to c) above). ~~and~~ Separation is carried out by demodulation with the corresponding signals of the carrier frequency method ~~that is~~ used. The signals x, yA and yB are supplied to the demodulation modules 63_1 to 63_3 that ~~which~~ demodulate them with ~~using~~ an operating frequency of the antiphase oscillation for 0° and 90°. The control

module 64 and ~~as well as~~ the electrode voltage calculation module 65 for regulation/calculation of the signals Fxl/r or Uxl/r, respectively, are preferably configured analogously to the electronics module 2 of ~~shown in~~ Figure 1. The control module 64 and the electrode voltage calculation module 65 (for regulation/calculation of the signals FyAo/u, UyAo/u, and FyBo/u, UyBo/u) are preferably designed analogously to the electronics module 2 of ~~shown in~~ Figure 2.

Figure 4 is a block diagram of an embodiment of a control system for incorporation into a mass system in accordance with Figure 3. It shows one preferred embodiment of the control system ~~that is~~ identified by the reference number 64 in Figure 3. The control system 64 includes ~~has~~ a first to third part 64_1 to 64_3. The first part 64_1 has a first regulator 80, a frequency generator 81, a second regulator 82, an electronics component 83, an addition stage 84 and a multiplier 85. The ~~method of~~ operation of the first part corresponds essentially to that ~~the method of operation~~ of the electronics module 2 of ~~shown in~~ Figure 1 and will therefore not be described once again ~~here~~. The second part 64_2 has a first regulator 90, a first modulator 91, a second regulator 92, a second modulator 93 and a third regulator 94. A first and a second addition stage 95, 96 are also provided. A rotation rate signal Ω can be determined at the output of the first regulator 90, and an assembled signal

comprising a quadrature bias B_Q and an acceleration A can be determined at the output of the third regulator 94.

The third part 64_3 of the control system 64 has a first regulator 100, a first modulator 101, a second regulator 102, a second modulator 103 and a third regulator 104. A first and a second addition stage 105, 106 are also provided. A rotation rate signal Ω with ~~a~~ negative mathematical sign can be tapped off at the output of the first regulator 100 and an assembled signal comprising the quadrature bias B_Q with ~~a~~ negative mathematical sign and an acceleration signal A can be tapped off at the output of the third regulator 104. The method of operation of the second and of the third parts ~~part~~ 64_2 and 64_3 corresponds to that of the electronics module 2 illustrated in Figure 2, and will therefore not be explained ~~once~~ again ~~here~~.

Only the signals for resetting ~~of the~~ rotation rate and ~~the~~ quadrature, after ~~the~~ multiplication by the operating frequency, are passed, together with the DC voltages for the quadrature auxiliary regulator, to a combined electrode pair. The two signals are therefore added so that the calculation of the electrode voltages includes the reset signals for ~~the~~ oscillation frequency and the DC signal for quadrature regulation. The electrode voltages Uxl/r, UyAo/u and UyBo/u thusly calculated ~~in this way~~ are

then added to the carrier frequency signals and ~~are~~ jointly passed via the analog/digital converters 66_1 to 66_6 to the electrodes.

The carrier frequency methods described above with antiphase excitation have the advantage that a signal is applied to the amplifier 60 only when the linear oscillators 3_1, 3_2, as well as 4_1 and 4_2, are deflected. The frequency signals ~~which are~~ used for excitation may be discrete frequencies or square-wave signals. Square-wave excitation is preferred, as it is easier to produce and process.

A number of analyses relating to ~~the~~ measurement accuracy of the acceleration measurement method according to the invention are ~~will also be~~ described in the following text.

~~The~~ Rotation rate results in an antiphase deflection of the oscillators 4_1 and 4_2 at the operating frequency of the Coriolis gyro. In contrast, acceleration results in ~~an~~ in-phase deflection of the oscillators 4_1 and 4_2 with ~~in which case~~ the acceleration ~~can be~~ measured in the frequency range from 0 Hz to about 500 Hz with a measurement accuracy of 50 mg to 50 ìg.

The in-phase deflection to be measured is given by:

$$\alpha = \frac{a}{\ell \cdot \omega^2}$$

α Deflection angle

a Acceleration

ℓ Length of the spring

ω Natural frequency of the oscillators 4_1 to 4_2.

For typical natural frequencies $\omega = 2 * \pi f = 6000$ rad/s to 60000 rad/s and spring lengths of $\ell = 1$ mm of Coriolis gyros, the measurement accuracy of, for example 5 mg is:

$\alpha = 1.4*10^{-6}$ to $1.4*10^{-8}$ rad or $x_2=x_1=1.4$ nm to 14 pm.

Small deflections such as the above ~~these~~ are difficult to measure in the frequency range from 0 to 500 Hz. At a minimum ~~the least~~, ~~this requires~~ additional electronic complexity is required for the multisensor according to the invention as ~~because~~ the electronics have to measure very accurately in both the operating range of the gyro function (rotation rate measurement) from 1 to 10 KHz and in the operating range for measurement of the acceleration from 0 to 500 Hz.

This disadvantage can be overcome in ~~according to~~ the invention by using the quadrature regulation, as described above, for a mass system comprising two linear oscillators (Figures 1 and 2) for the mass system composed of four linear oscillators

(Figure 3): the acceleration detunes the orthogonality error, ~~thus~~ resulting in an in-phase quadrature signal, ~~which can~~ clearly ~~be~~ seen, at the operating frequency in the oscillators 4_1 and 4_2:

$$\Omega_Q = \frac{a_Q}{a_s} \cdot \frac{\omega}{2} = \alpha \frac{\omega}{2}$$

In this case, Ω_Q is the quadrature rotation rate, a_Q is the quadrature acceleration and a_s is the oscillator acceleration.

For a measurement accuracy of, for example 5 mg ($\alpha = 1.4.10^{-6}$ rad), this results in:

$\Omega_Q = 0.0042 \frac{rad}{s} = 0.25°/s = 866°/h$ at a natural frequency of 1 kHz

$\Omega_Q = 4.2 \cdot 10^{-5} \frac{rad}{s} / 0.0025°/s = 8.7°/h$ at a natural frequency of 10 kHz

For a rotation rate sensor of 5°/h, the quadrature rotation rate of 866°/h can be verified with certainty using the same electronics. ~~while,~~ In contrast, at the natural frequency of 10 KHz and with the quadrature rotation rate of 8.7°/h, the verification limit of the rotation rate sensor of 5°/h is virtually exhausted. Although this measurement is also stable in the long <u>run</u> ~~term~~, it depends on the long-term stability of the quadrature rotation rate. The actual quadrature rotation rate is an antiphase

signal. The stability of the acceleration measurement therefore depends on the difference in the quadrature rotation rates from the oscillator 4_1 to the oscillator 4_2, and their stability. Since the two oscillators are located close to one another and were manufactured in one process step, it is predicted that it is possible to cover a range with low accuracy from 50 mg to 50 μg.

While this invention has been described with reference to its presently preferred embodiment, it is not limited thereto. Rather, the invention is limited only insofar as it is defined by the following set of patent claims and includes within its scope all equivalents thereof.

~~Patent Claims~~

What is claimed is:

1. A Coriolis gyro (1'), having a first and a second resonator (70_1, 70_2), which are each in the form of a coupled system comprising a first and a second linear oscillator (3_1, 3_2, 4_1, 4_2), with the first resonator (70_1) being mechanically/electrostatically connected/coupled to the second resonator (70_2) such that the two resonators can be caused to oscillate in antiphase with one another along a common oscillation axis (72).

2. The Coriolis gyro (1') as claimed in claim 1, characterized in that the configurations of the first and of the second resonator (70_1, 70_2) are identical, with the resonators (70_1, 70_2) being arranged axially symmetrically with respect to one another with respect to an axis of symmetry (73) which is at right angles to the common oscillation axis (72).

3. The Coriolis gyro (1') as claimed in claim 1 or 2, characterized in that the first oscillators (3_1, 3_2) are each connected by means of first spring elements (5_1 - 5_8) to a gyro frame (7_1 - 7_{14}) of the Coriolis gyro, and the second oscillators (4_1, 4_2) are each connected by second spring elements (6_1 - 6_4) to one of the first oscillators (3_1, 3_2).

4. The Coriolis gyro (1') as claimed in claim 3, characterized in that the second oscillators (4_1, 4_2) are attached/clamped in at one end to the first oscillators (3_1, 3_2) by means of the second spring elements (6_1 - 6_4) and/or the first oscillators (3_1, 3_2) are attached/clamped in at one end to a gyro frame of the Coriolis gyro by means of the first spring elements (5_1 - 5_8).

5. The Coriolis gyro (1') as claimed in claim 3 or 4, characterized by a device for production of electrostatic fields, by means of which the alignment angle of the first spring elements (5_1 - 5_8) with respect to the gyro frame can be varied, and/or the alignment angle of the second spring elements (6_1 - 6_4) with respect to the first oscillators (3_1, 3_2) can be varied.

6. The Coriolis gyro (1') as claimed in claim 5, characterized by

- a device (10_1 - 10_8, 11_1 - 11_4) by means of which it is possible to determine first signals for the rotation rate and quadrature bias, which occur within the first resonator (70_1), and second signals for the rotation rate and quadrature bias, which occur in the second resonator (70_2),
- control loops (60 - 67) by means of which the alignment/strength of the electrostatic fields is regulated such that the first and the second quadrature bias are each as small as possible, and
- a computation unit, which uses the first and second signals to determine the rotation rate, and uses an in-phase component of the electrostatic fields which compensate for the first and second quadrature biases to determine the acceleration to be measured.

7. A method for selective or simultaneous measurement of rotation rates and accelerations using a rotation rate Coriolis gyro (1') which has a first and a second resonator (70_1, 70_2) which are each in the form of a coupled system comprising a first and a second linear oscillator (3_1, 3_2, 4_1, 4_2), with the rotation rates being determined by tapping and evaluation of the deflections of the second oscillators (4_1, 4_2), having the following steps:

- the two resonators (70_1, 70_2) are caused to carry out oscillations in antiphase with one another along a common oscillation axis (72),
- the deflections of the second oscillators (4_1, 4_2) are compared with one another in order to determine an antiphase deflection component which is a measure of the rotation rate to be measured and/or in order to determine a common in-phase deflection component, which is a measure of the acceleration to be measured,
- calculation of the rotation rate/acceleration to be measured from the in-phase deflection component/antiphase deflection component.

8. The method as claimed in claim 7, characterized in that the common in-phase deflection component is determined as follows:

- a first quadrature bias is determined which occurs within the first resonator (70_1),
- a second quadrature bias is determined which occurs within the second resonator (70_2),
- the first quadrature bias is calculated using the second quadrature bias in order to determine a common quadrature bias component which is proportional to the acceleration to be measured and represents the common in-phase deflection component.

9. The method as claimed in claim 8, characterized in that electrostatic fields are produced in order to vary the mutual alignment of the first and second oscillators (3_1, 3_2, 4_1, 4_2), with the alignment/strength of the electrostatic fields being regulated such that the first and the second quadrature bias are each as small as possible.

~~Method for measurement of rotation rates/accelerations using a rotation rate Coriolis gyro, as well as a Coriolis gyro which is suitable for this purpose~~

ABSTRACT

A Coriolis gyro includes ~~(1') has~~ a first and a second resonator, ~~(70_1, 70_2), which are~~ each in the form of a coupled system comprising ~~a~~ first and ~~a~~ second linear oscillators. ~~(3_1, 3_2, 4_1 and 4_2), in which case~~ The first resonator ~~(70_1) together with (70_2)~~ can be caused to oscillate in antiphase with respect to ~~one another~~ the second resonator along a common oscillation axis. ~~(72)~~ A system ~~which is~~ coupled in this way has the advantage that it is possible to measure ~~the~~ rotation rate and acceleration ~~accelerations~~ simultaneously, with insensitivity to disturbances ~~and that it is insensitive to disturbance influences, for example~~ (e.g., externally or internally acting vibrations).

~~(Figure 3)~~